MANAGING A SUSTAINABLE FARMING SYSTEM IN THE DRY ZONE OF SRI LANKA*

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SUMMARY

In this investigation which lasted three seasons, three aspects of weed control in Sri Lanka were studied. Firstly, no-till techniques and crop residue mulches were examined. Results indicated that herbicides were more effective than conventional tillage practices in controlling weeds. Crop yields were often much higher in no-till plots than in tilled plots. Compared with the unmulched plots, those mulched with rice straw at 4 and 8 t/ha reduced the weed dry matter by 22.4 and 40.6 percent respectively. Crop yields showed linear responses to these mulching regimes.

Secondly, the use of live-mulch systems with creeping leguminous covers was studied. Suppression of weeds was high with legume covers and relatively high yields were obtained with *Phaseolus atropurpureus* live-mulch covers.

Thirdly, the use of leguminous shade trees was examined. Shade under *Leucaena leucocephala* in 2 m wide avenues reduced weed growth considerably.

The significance of developing an integrated system based on these techniques suitable for upland cropping in the dry zone of Sri Lanka is discussed.

INTRODUCTION

Weeds present a very serious problem in upland agriculture in the dry zone of Sri Lanka. Several investigations have shown that weed proliferation has resulted in the adoption of shifting cultivation (Stockdale, 1926; Joachim and Kandiah, 1948). Abeyratne (1962) stated that weed control is a major factor contributing to better management of an upland farming system in the dry zone.

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Abeyratne (1956, 1962) has discussed the use of tillage for weed control in the dry zone. In fact, tillage practices have been used more frequently to control weeds than any other method. However, there appears to be a serious conflict in tillage operations between the benefits from weed control and the undesirable effects on soil erosion due mainly to heavy rainfall. If tillage practices are to be successful in controlling weeds without enhancing soil erosion, they must leave a protective residue on the soil surface.

Various mulches have been found to effectively reduce weed growth (Webster and Wilson, 1966; Abeyratne, 1956; Kirinde, 1957). The effectiveness of the mulches in preventing weed growth is thought to be a reduction in light intensity (Webster and Wilson, 1966).

Traditionally, forest or bush fallow have been used to control weeds in shifting cultivation systems (Joachim and Kandiah, 1948). The fallow period which is characteristic of this system rejuvenated the soil fertility, restored a desirable soil structure and controlled weeds. This system, however, requires an extensive farmland although it does not require costly inputs.

Unfortunately, the rapid increase in population of Sri Lanka over the past few decades has disrupted shifting cultivation as a traditional system of farming in the dry zone. The limited arable land has been used quite intensively for cropping, which ultimately reduced the fallow period. This change in cropping patterns in turn has caused many problems. For example, exposure of large areas of bare soil for long periods has greatly enhanced the extent of erosion (Darwent, 1981). Long cropping periods followed by short fallow periods have led to a considerable depletion of nutrient status of the soil, with control of grass weeds being a more serious problem than broad-leaved weeds (Kirinde, 1957).

The dry zone of Sri Lanka has a high potential for adopting a productive and sustainable farming system. The objective must be to plan a strategy to overcome the decline of soil productivity and to evolve a stable and productive agricultural system. The end result would be better control of weed growth under these conditions.

METHODS AND MATERIALS

Field studies were conducted at the Regional Agricultural Research Station in Maha Illuppallama, Sri Lanka. The soil type was predominantly Reddish Brown Earth which apparently has a low water holding capacity. A characteristic feature of this soil type is that it loses water and hardens quickly as the rain subsides.

In many parts of the dry zone there are two cropping seasons, namely "Maha" (October to January) and "Yala" (March to July).

In all experiments, the herbicide applications were controlled droplet application (CDA) at 40 l/ha using a Micron Herbi Applicator. The seeding was done by using a Rolling Injection Planter, developed by the International Institute of Tropical Agriculture (IITA) in Nigeria.

Experimental Procedures

Conventional Tillage versus Zero Tillage. Conventional manual tillage followed by "mammoty" (hoe) weeding as practised by local farmers was compared with a zero tillage method. The experiment was carried out for several successive seasons with appropriate crop rotations.

Glyphosate at the rate of 4 l/ha (formulated product) was sprayed onto the existing weeds and the crop was injection - planted into the resulting mulch. Mixtures of metobromuron and metolachlor ('Galex') and alachlor and atrazine ('Primextra') at doses of 3 l/ha (formulated product) and 4.5 l/ha (formulated product) respectively were used as pre-emergence herbicides for cowpea *(Vigna unguiculata* L.) and maize *(Zea mays* L.) No pre-emergence herbicides were used for sesame *(Sesamum indicum* L.) and finger millet (*Eleusine coracana* L. Gaertn.)

Two "mammoty" weedings 15 and 30 days after seeding were carried out in the tilled plots.

Use of Crop Residue as Mulch. An experiment was conducted with tillage versus no tillage, chemical weeding versus no weeding, and three levels of rice straw (0, 4 and 8 t/ha). Cowpea was injection-seeded, fertilized and a mixture of metobromuron and metolachlor at a dose of 3 l/ha (formulated product) was applied to the appropriate plots, soon after which the plots were mulched.

Use of Live Mulches. *Phaseolus artropurpureus* (Siratro), *Centrosema pubescens* (Centro) and *Pueraria phaseoloides* (Kudzu) were used as live mulches in this investigation with a cover of weeds serving as the control.

Covers of all these legumes were sprayed with a growth regulator CGA 47283 (Ciba-Geigy) at a dose of 8 kg/ha followed 5 days later by 2 l/ha of paraquat. Weeds in the control no-tilled plots were sprayed with glyphosate. Paraquat spraying was found necessary to dessicate the dense leafy legume cover through which crop emergence would have been difficult. Each plot was injection - seeded with maize. No fertilizer was added.

Avenue Cropping or Alley Cropping or Sylvi-agriculture. Rows of tree legume (*Leucaena leucocephala* (Ipil-ipil) were grown in avenues 2 m wide (0.5 m within row spacing) and compared with bare plots. One half of each plot was tilled and tree loppings in the legume plots were incorporated. In the other half, loppings were spread on the ground and crops established no-till. Each sub-plot with legume trees accommodated two lopping treatments, *viz.* 0.5 m and 1.0 m above ground. Thereafter, maize and cowpea were established. The foliage of *L. leucocephala* was lopped prior to crop establishment and later twice before harvesting the crops. No fertilizer was added.

RESULTS AND DISCUSSION

Till *vs* No-Till. The major weed in the field at the beginning of "Maha" 1980/81 season was *Cynodon dactylon.* Continuous cultivation and the use of herbicides gave a shift in weed population, *C. dactylon* dominated in ploughed plots, but broad-leaved species, such as *Tridax procumbens, Crotalaria anagyroides, Acanthospermum hispidum, Euphorbia heterophylla, Cleome viscosa* and grasses such as *Echinochloa colona, Digitaria adscendens, Dactyloctenium aegyptium* and *Chloris barbata* were dominant in no-till plots.

Table 1. Effect of Tillage on Weed Growth

Treatment	*Weed Dry Weight (g/m^2)* "Yala" 1981	"Maha" 1981/82 a	"Maha" 1981/82 b	"Yala" 1982 a	"Yala" 1982 b
Tilled	33.8	48	74	105	84
No-tilled	10.4	25	77	66	178
LSD (P=0.05)	8.3	12	NS	20	NS
Cowpea crop	23.0	39	89	97	107
Sesame crop	21.2	—	—	74	155
Maize crop	—	34	62	—	—
LSD (P=0.05)	—	NS	25	11	NS

a=measured 15 days after sowing
b= ,, 30 ,, ,, ,,

Excellent control of weeds was achieved in no-till plots (P=0.01) (Table 1). Despite "mammoty" weeding of the tilled plots at 15–day intervals after planting *C. dactylon* growth was rather heavy. In no-till plots during "Yala" 1982 weed regeneration was considerable, probably due to the reduced efficacy of the metobromuron and metolachlor mixture because of insufficient rainfall after application.

The reason for inconsistent weed growth in most cropping situations is not clear. However, weeding after 15 days in tilled plots will have affected the weed growth as well as crop development.

Table 2. Effect of Tillage on Crop Yields (Kg/ha)

	"Yala" 1981		*"Maha" 1981/82*		*"Yala" 1982*	
Treatment	*Cowpea*	*Sesame*	*Cowpea*	*Maize*	*Cowpea*	*Millet*
Tilled	467	150	348	366	854	394
No-till	706	474	528	549	844	670
LSD (P=0.05)	93	96	157	191	NS	112

Table 2 shows that higher yields could be obtained from no-till plots. The lower yields of crops for the tilled plots may reflect the competitive ability of *C. dactylon* rather than tillage *per se*. Despite yields being very low in "Yala" 1981 and "Maha" 1981/82 due to drought conditions, the no-till plots gave a much-higher crop yield (P=0.05) than tilled plots. This may be due to a better retention of soil moisture in the mulched no-till plots.

Crop Residue Mulches. A significant reduction (P=0.05) in weed dry matter yields was observed in the no-till plots (Table 3).

Table 3. Effect of Tillage on Weed Growth

Treatment	*Weed Dry Wt.* (g/m^2)
Tilled	13.8
No-till	8.7
LSD (P=0.05)	1.4

Furthermore, there was a significant linear reduction (P=0.05) in the weight of weed dry matter when straw mulches were added (Table 4).

Table 4. Effect of Mulch on Weeds (g/m^2)

Treatment	*Weed Dry Wt.*
No mulch	14.3
Mulching 4 t/ha	11.1
Mulching 8 t/ha	8.5
LSD (P=0.05)	5.4

A highly significant interaction (P=0.01) was observed between tillage and weeding and the yield of cowpea (Table 5).

Table 5. Effect of Tillage and Chemical Weeding on Cowpea Yield (kg/ha)

Treatment	*Tilled*		*No-till*
Chemical weeding	534		608
No weeding	277		552
Between tillage LSD (P=0.05)		67	
Between weeding LSD (P=0.05)		166	

It is clear from the above results that the mixture of metabromuron and metolachlor appreciably increased the crop yield of cowpea in tilled plots.

Table 6. Effect of Mulch on Cowpea Yield (kg/ha)

Treatment	*Yield*
No mulch	362
Mulching 4 t/ha	491
Mulching 8 t/ha	625
LSD (P=0.05)	65

Table 6 shows that cowpea yields increased linearly (P=0.05) with increasing rate of mulching. Each tonne per hectare of mulch resulted in a 33 kg/ha increase in cowpea yield. This suggests that a decreased weed growth was responsible at least in part for the increased cowpea yields.

Live Mulches. *P. atropurpureus* and *C. pubescens* re-established themselves satisfactorily following paraquat treatment. However, the application of paraquat nearly killed *P. phaseoloides* and its re-growth was poor.

Leguminous covers did not appear to show any significance in controlling weed growth until 30 days after sowing. At the second observation (i. e., 55 days after sowing), *C. pubescens* and *P. atropurpureus* appeared to suppress weed growth while in the weakened *P. phaseoloides* and no-till plots, the weed cover increased (Table 7).

Table 7. Effect of Live-mulch Cover on Weed Growth (g/m²)

	Sample time	
Mulch	*30 days*	*55 days*
C. pubescens	29.2	15.6
P. phaseoloides	41.4	74.0
P. atropurpureus	48.0	32.2
Weed cover	47.2	89.4
LSD (P=0.05)	NS	56.0

Table 8. Effect of Live-mulch Cover on Maize Yield (kg/ha)

Mulch	*Yield*
C. pubescens	898
P. phaseoloides	1,226
P. atropurpureus	1,459
Weed cover	588
LSD (P=0.05)	334

Table 8 shows that maize yields were greater in live-mulch plots than in bare plots (P=0.05). Although there was no appreciable difference in maize yields under *P. atropurpureus* and *P. phaseoloides* covers, the highest maize yield was obtained in the live mulch plots in which *P. atropurpureus* was maintained. Maize yields in live–mulch covers were not related to weed growth.

Avenue Cropping. It is interesting to note that weed growth was much lower (P=0.05) in *L. leucocephala* avenues than in the control (Table 9). This could be the result of dense shade occurring under profusely growing *L. leucocephala* during the 'off' or non-arable season. However, there was no effect of tillage or lopping heights on the growth of weeds (Table 10).

Table 9. Effect of Avenue Cropping on Weed Growth (g/m²)

Treatment	*Maize*	*Cowpea*
Leucaena	19	17
Control	96	123
LSD (P=0.05)	20	35

Table 10. Total Dry Matter Yield (Kg/ha) of Leaf and Stem from three loppings during "Maha" 1981

	Lopping height (m)					
	0.5		1		*Mean*	
	Leaf	*Stem*	*Leaf*	*Stem*	*Leaf*	*Stem*
Tilled	1,719	3,051	2,755	2,963	2,737	3,007
No-till	2,889	3,085	2,986	3,166	2,938	3,125
Mean	2,804	3,068	2,871	3,065	2,838	3,066

Total biomass productivity, which was comparable for tilled and no-till plots, was an average of 3 ton stems (wood) and 2.8 ton leaf (dry weight basis per hectare). Thus, apart from mulch and organic carbon, the leaf material alone would have added approximately 90 kg N, 9 kg P per ha in one cropping season (Weerakoon, 1982).

Table 11 Average Yields of Different Crops (kg/ha)

Treatment	*Maize*		*Cowpea*
Leucaena	728		424
Control	579		499
LSD (P=0.05)		113	
Within control			
Tilled	522		428
Nó-till	633		569
LSD (P=0.05)		125	

Crop yields were again low on account of the drought that prevailed during the cropping season.

However, maize performed better in the avenues of *L. leucocephala* than in the bare plots, whilst cowpea yields were the same under both treatments, suggesting that the alley width may have some adverse effects on the growth of cowpea (Table II).

Herbicides have emerged as a practical alternative to tillage for controlling weeds without much disturbance or exposure of the soil. Furthermore, results showed that effective weed control could be achieved if crop residue mulches (e. g., paddy straw) are incorporated into the system. In both situations, desiccated weed trash or straw function as a surface mulch to protect the soil against erosive forces of rain (Greenland, 1975) and depletion of organic matter, due to direct exposure to sunshine, as stated by Lal (1981).

The fast growing perennial legumes have the advantage of smothering weeds more efficiently and provide adequate protection to the soil. In addition, the planting of leguminous covers helps to recycle a substantial quantity of nutrients as a result of organic litter being added to the soil (Tan *et al*, 1976).

An integration of permanent tree crops with seasonal food crops in avenue cropping technique, has the advantage of natural recycling of fertility and minimising weeds through shading, while providing vital by-products such as fuelwood and fodder. Thus, avenue cropping has the greatest potential for developing a stable and sustainable productive system for intensive cropping which can replace the wasteful shifting cultivation practice in the dry zone of Sri Lanka.

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